DIRECT TESTIMONY OF

SCOTT ROBINSON

ON BEHALF OF

DOMINION ENERGY SOUTH CAROLINA, INC.

DOCKET NO. 2023-9-E

Q. PLEASE STATE YOUR NAME, BUSINESS ADDRESS, AND OCCUPATION.

A. My name is Scott Robinson. I am a Director at Guidehouse and lead the Mobility Analytics team within the Technology Advisory group. My business address is 1375 Walnut Street, Boulder, CO. Today, I will be filing testimony on behalf of Dominion Energy South Carolina, Inc. ("DESC").

Q. BRIEFLY STATE YOUR EDUCATION, BACKGROUND, AND EXPERIENCE.

A. I have Masters degrees from the University of Texas at Austin's Jackson School of Geoscience in the Energy and Earth Resources program, and the University of Texas at Austin's Lyndon B. Johnson School of Public Affairs. I have published multiple peer reviewed journal articles on modeling the adoption of distributed energy resources.[1] For the last nine years, I have modeled transportation

[1] Robinson, S. A., & Rai, V. (2015). Determinants of spatio-temporal patterns of energy technology adoption: An agent-based modeling approach. *Applied Energy*, *151*, 273-284; Rai, V., & Robinson, S. A. (2013). Effective information channels for reducing costs of environmentally-friendly technologies: evidence from residential PV

electrification, distributed energy resources, and energy efficiency adoption, economics, and impacts at Guidehouse. My clients include state and local governments, utilities, utility regulatory agencies, and Original Equipment Manufacturers ("OEMs") on topics related to the modeling and impact of technology adoption, including electric and alternative fuel vehicles. I developed the mathematics and code base of Guidehouse's Vehicle Analytics and Simulation Tool ("VAST") and have conducted electrification studies in 18 states.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC SERVICE COMMISSION OF SOUTH CAROLINA (THE "COMMISSION")?

A. Yes. I testified before the Commission in Dockets 2019-182-E, and 2020-229-E.

Q. HAVE YOU INCLUDED ANY EXHIBITS WITH YOUR TESTIMONY?

A. Yes, I have attached our final report to DESC, "2023 IRP Forecast: DESC Electric Vehicle & Charging Infrastructure" ("Guidehouse 2023 EV Study"), as Exhibit __ (SR-1).

Q. WHAT ARE YOUR RESPONSIBILITIES AT GUIDEHOUSE?

A. I am an expert in quantitative forecasting and simulation of alternative fuel vehicle, energy efficiency technologies, electrification, and distributed energy generation technologies. I lead teams of modelers to forecast the impacts of these

markets. *Environmental Research Letters*, *8*(1), 014044; Rai, V., & Robinson, S. A. (2015). Agent-based modeling of energy technology adoption: Empirical integration of social, behavioral, economic, and environmental factors. *Environmental Modelling & Software*, *70*, 163-177.

technologies on our clients' customer bases, assets, and core business. I am responsible for several of our flagship techno-economic models including DSMSim, DERSim, GRIP, and VAST which was used to develop the electric vehicle forecast for DESC. My responsibilities at Guidehouse include mathematical and theoretical model specification, quality control, managing model feature integration, quality and version control, model enhancement planning, and project leadership. I frequently fill the role of technical quality manager, senior modeler, subject matter expert, lead modeler, or quality control lead on projects utilizing our models.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to report on the methodology and results of the Guidehouse analysis on vehicle electrification that fed into DESC's Integrated Response Plan ("IRP").

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. Guidehouse developed a forecast for light, medium, and heavy-duty electric vehicle adoption, charging, and load impacts to support Dominion South Carolina Integrated Resource Planning process. As an outcome of this analysis, Guidehouse forecasts that between 2023 and 2037, electric vehicles sales in Dominion South Carolina will grow by 5,927%, resulting in 464,678 plug-in electric vehicles ("PEV") on the road by end-of-year 2037. Charging for these vehicles is forecast to be supplied by 108,973 Level 1 ("L1"), 251,824 Level 2 ("L2"), and 9,660 Direct

Current Fast Charging ("DCFC") ports[2] by the end of the forecast. By 2037, the charging of electric vehicles in the territory will result in 1,803 GWh of sales, and 327.9 MW of coincident peak demand[3] in the territory.

This growth is driven by a combination of a near-universal shift in OEM investment to battery-electric powertrains, increasing customer demand, and strong policy support. Energy and peak demand impacts will be further accelerated by increasing fleet vehicle electrification and rated capacity (nameplate kW) of electric vehicle charging station ports. Medium and heavy-duty PEV adoption is expected to ramp up in the next 3-5 years as OEM production increases. Growth in electrification and associated impacts is expected to continue throughout the forecast horizon.

Q. WHICH VAST MODULES WERE USED BY GUIDEHOUSE IN SUPPORT OF THE IRP?

A. The VAST suite was used to forecast the resource requirements on DESC's electric system caused by load additions from electric vehicles. As such, Guidehouse deployed the VAST Adoption Module, VAST Charging Infrastructure Module, and VAST Load Impacts Module. These modules were run in serial to forecast the number of electric vehicles on the road in the service territory, determine the electric vehicle supply equipment ("EVSE") required to charge these vehicles, and to simulate the load shapes, energy (kilowatt hour), and coincident

[2] The terms "ports" or "chargers" refer to electric vehicle charging station ports.
[3] 2037 Coincident peak demand was calculated assuming a system peak hour from 4pm – 5pm in August

peak demand (kilowatt) associated with the charging behavior of vehicles refueling on the charging network in the DESC territory.

Q. BRIEFLY DESCRIBE THE METHODOLOGY AND ASSUMPTIONS IN THE ELECTRIC VEHICLE ADOPTION FORECAST.

A. Guidehouse's VAST Adoption Module uses a structural modeling framework to forecast adoption of various powertrain-fuel and vehicle class configurations in the PEV market at the census tract level. VAST is a systems dynamics model[4] that uses enhanced Bass Diffusion[5], conditioned on vehicle availability,[6] customer ownership economics,[7] and eligibility constraints.[8] By modeling vehicle adoption based on data specific to Dominion Energy South Carolina such as vehicle sales, vehicle registrations, vehicle miles traveled, charging station port counts, fuel costs, etc., the forecast closely reflects local market conditions. Guidehouse uses a calibrated enhanced Bass Diffusion model to forecast new vehicle sales split between competing powertrains and vehicle classes and fits the parameters of this model to nine years of historical localized data. The calibration routine is a training process that runs the model against actual registration and sales records to find the best set of fitting parameters.

[4] Sterman, John. *Business dynamics*. Irwin/McGraw-Hill c2000., 2010.
[5] Bass, Frank (1969). "A new product growth model for consumer durables." *Management Science 15 (5): p 215-227*
[6] Vehicle availability is modeled based on public OEM model release schedules and historic trends by powertrain, duty, and class.
[7] Customer economics are calculated as the total cost of vehicle ownership, assuming an average 3-year ownership period.
[8] Customer eligibility is calculated as a function of charging access, which increases for multi-unit dwelling customers over time.

Q. BRIEFLY DESCRIBE THE METHODOLOGY AND ASSUMPTIONS IN THE CHARGER COUNT FORECAST

A. VAST was designed to forecast the charging needs of vehicles on the road by technology (L1, L2, DCFC) and use-case (Home, Public Market, Workplace, Fleet Depot, Hub, Curbside Residential, etc.). This EVSE creates a network from which vehicles may charge given the compatibility of a EVSE use-case and the vehicle type. Fueling infrastructure and vehicle populations evolve together in VAST. A lagging transition function models the movement of the EVSE market toward equilibrium, and additional EVSE reduces market barriers to new sales.

More vehicles on the road with specific fuel requirements dictated by the powertrain stimulate infrastructure development for the relevant fuel. This is accomplished through the estimation of dynamic regional vehicle-per-charger ratios. They are regional, reflecting local traffic and driving patterns, and dynamic, reflecting changing technology, range, and use case preferences among drivers. Charging levels (rated capacity of the chargers) evolve over time in the model in response to vehicle range, penetration, and use case requirements. The ratio begins with current port counts in service and moves toward a long-run equilibrium. For public charging, the long-run ratio is calculated in NREL's EVI-Pro model.[9]

[9] https://www.nrel.gov/transportation/evi-pro.html

Q. BRIEFLY DESCRIBE THE METHODOLOGY AND ASSUMPTIONS IN THE ELECTRIC VEHICLE LOAD FORECAST

A. Guidehouse's VAST Load Forecasting module simulates the load impacts of the interacting vehicle and charger ecosystem. Each vehicle class and duty combination has an associated efficiency (miles per kWh)[10], and vehicle miles traveled.[11] The efficiency is a function of the vehicle configuration (frontal area of the vehicle, drag, weight, etc.) and local climatic conditions (humidity, operating temperatures). The total annual energy requirements from each vehicle type are then associated with the relevant charging use-cases, each of which has a distinct load shape.[12] Peak capacity impacts are then derived directly using the on-peak window[13] for the company.

Q. PLEASE STATE THE KEY FINDINGS OF THE ELECTRIC VEHICLE FORECAST AS THEY RELATE TO THE IRP.

A. *Plug-In Electric Vehicle ("PEV") Adoption:*

The table below shows the total forecasted PEV sales, PEV population, and PEV market share of vehicle sales in Dominion Energy South Carolina territory for end of years 2023, 2030 and 2037:

[10] Alternative Fuels Data Center (https://afdc.energy.gov/)
[11] Federal Highway Administration (https://highways.dot.gov/)
[12] Sourced from Guidehouse EVSE Loadshape Database
[13] On-peak window varied by month based on the forecast year with reference to DESC's supplied load forecast.

Table 1. PEV Sales and Population in DESC Service Territory

Year	Total PEV Sales	Total PEV Population	PEV Sales %
2023	2,820	7,841	3.7%
2030	32,060	115,195	40%
2037	61,862	464,678	76%

The proportion of BEVs in the forecasted PEV vehicle mix grows over time, as shown in the table below:

Table 2. PEV Sales and Population by Powertrain in DESC Service Territory

Year	BEV % of PEV Sales	PHEV % of PEV Sales	BEV % of PEV Population	PHEV % of PEV Population
2023	76.8%	23.2%	69.1%	30.9%
2030	93.9%	6.1%	90.1%	9.9%
2037	94%	6%	93.6%	6.4%

Plug-in electric medium-duty and heavy-duty ("MDHD") vehicles[14] are in the beginning stages of electrification. The total number of forecasted MDHD PEVs is shown in the table below. Overall, PEVs are forecast to make up 3.65% of the total MDHD vehicle fleet by 2030. 95% of these vehicles are forecast to be full battery electric.

[14] MDHD vehicles refer to vehicles belonging to Gross Vehicle Weight Rating classes of 2b through 8

Table 3. Medium and Heavy Duty PEV Sales and Population in DESC Service Territory

Year	MDHD PEV Sales	MDHD PEV Population
2023	71	113
2030	596	2,727
2037	1,011	7,426

EVSE (Electric Vehicle Supply Equipment) Forecast:

The supply of EVSE follows the demand generated by electric vehicle refueling need. The table below shows the expected split of L1, L2, and DC ports[15] used for LDV charging in Dominion Energy South Carolina service area:

Table 4. Port Count in DESC Service Territory

Technology	2023 Port Count	2030 Port Count	2037 Port Count
L1	3,403	37,900	108,973
L2	4,215	61,251	251,824
DC	134	2,884	9,660

By use-case, public, workplace, Multi-Unit Dwellings ("MUDs") and curbside residential port additions are forecasted to grow consistently through the forecast horizon. Residential EVSE installed in Single Unit Dwellings ("SUDs") is

[15] The terms "ports" or "chargers" refer to electric vehicle charging station ports.

expected to constitute the majority of ports in the territory. In 2037, SUD ports are forecasted to make up around 91% of all ports used for LDV charging.

After SUD, workplace, MUDs and public use-cases are forecast to have the highest port counts by 2037. These uses-cases mostly support light-duty, individually owned vehicles. The table below shows the 2023 and 2037 port counts for the top four use cases.

Table 5. Port Counts by Top Four Use Cases in DESC Service Territory[16]

Use Case	2023 Port Counts	2037 Port Counts
SUD	7,050	331,582
Workplace	87	12,498
MUD	56	8,261
Market	425	6,620

Load Impacts:

PEV load growth stems directly from forecasted vehicle adoption and EVSE build-out trajectories, and as such, follows a similar path. The table below shows total PEV energy consumption and the PEV contribution to coincident peak for years 2023, 2030, and 2037.

[16] See exhibit SR-1 for the complete EVSE use case key.

Table 6. PEV Energy Consumption and Coincident Peak Load in DESC Service Territory

Year	Total PEV Energy Consumed (GWh)	PEV Contribution to Coincident Peak Load (MW)
2023	23.5	4.8
2030	436.2	81.3
2037	1,803.4	327.9

Q. WHAT ARE KEY DRIVERS OF THE ADOPTION FORECAST?

A. The most significant drivers for the projected growth in PEV adoption are (1) the announced investment and corresponding PEV sales targets and model releases by major automakers, (2) increasing customer demand for PEVs in South Carolina, and (3) the strong global policy support for PEVs and the feedback between policy and investment.

Specifically:

1. Current automaker investment, which is the strongest leading indicator of future model availability and production, points strongly in favor of diminishing internal combustion engine ("ICE") and hybrid vehicle ownership. Between 2025 and 2035, 11 of the 15 largest automakers have committed to at least 50% BEV sales targets. Even the four automakers (Toyota, Subaru, Honda, and Nissan) that have not committed to full battery electric vehicle sales targets have targets of at least 40% PEV sales. [17] Automaker PEV sales targets are backed by

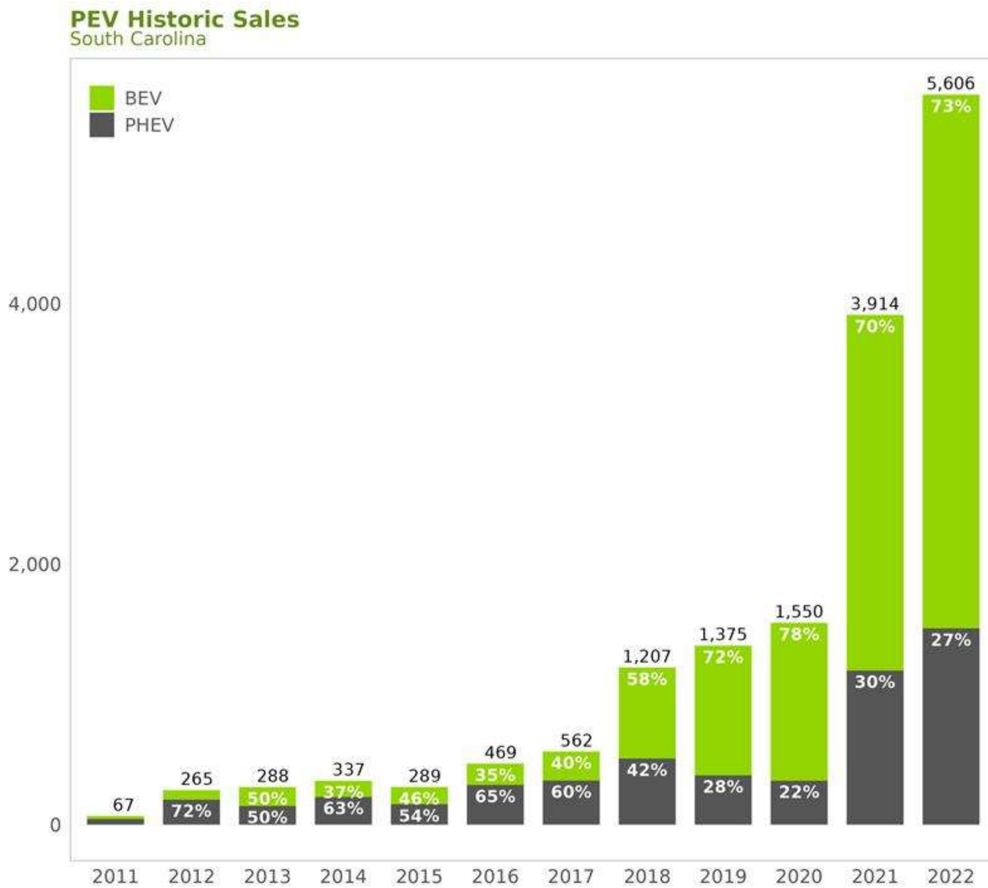
[17] These automakers expect to meet their targets with a combination of BEV and PHEV sales.

committed or planned investment, as worldwide, publicly released commitments sum to nearly $1.2 trillion for PEVs.[18]

2. Customer preference, as measured by vehicle sales, also indicates two important trends in South Carolina. First, overall demand for PEVs is growing exponentially, and second, that full BEV demand is increasing much more quickly than PHEVs. These trends are illustrated in Figure 1 below, showing South Carolina vehicle sales by PEV powertrain from 2011-2022. As public charging infrastructure expands, the current demonstrable customer preference for BEVs is expected to accelerate.

[18]https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/

Figure 1. Annual Sales of BEVs and PHEVs in South Carolina 2011-2022



3. Global policy. In the U.S., three major federal policies are expected to have substantial import on the South Carolina PEV market: zero emissions vehicle ("ZEV") policies and global ICE sales restrictions, Infrastructure Investment and Jobs Act ("IIJA"), and the 2022 Inflation Reduction Act ("IRA").

In the US, 40% of the new vehicle market is influenced by the California Air and Resource Board ("CARB") ZEV program or state programs mirroring the CARB standards. In effect, the standards require 100% of light-duty new vehicle sales to be ZEV by 2035. [19] This will affect other non-ZEV states like South Carolina as OEMs respond to shrinking ICE markets. Since vehicle markets are global in scope, this is compounded by similar policies in Europe and Asia.[20]

The IIJA provides policy support to PEVs through the National Electric Vehicle Infrastructure Formula Program ("NEVI"), the Charging and Fueling infrastructure Grants, Low or No Emission (Bus) Grants, and the Clean School Bus Program. The NEVI plan and the Charging and Fueling Infrastructure Grants promote PEV adoption through the reduction of range anxiety by the deployment of more public ports. The grants available for buses will pull forward the electrification of bus fleets.

The IRA removed OEM-specific caps on federal tax credits, but limited vehicle eligibility based on price and North America-based production.[21] As OEMs shift production to match IRA incentive requirements, the effective size of the credit to the average customer will increase. By reducing effective MSRP,[22] the IRA is expected to increase customer demand for PEVs.

Q. WHAT ARE KEY DRIVERS OF THE EVSE FORECAST?

A. LDV and MHDV charging needs are expected to be met by L1, L2, and DCFC technologies, with L2 and DCFC usage growing throughout the forecast horizon. Customers will continue to use L1 as an option for home charging use-

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[19] https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program
[20] https://www.iea.org/data-and-statistics/data-tools/global-ev-policy-explorer
[21] https://www.congress.gov/bill/117th-congress/house-bill/5376/text
[22] https://afdc.energy.gov/laws/electric-vehicles-for-tax-credit

cases due to lower VMT, longer potential charging windows, the additional expense and coordination of installing an L2 charger, the existence of older homes where electrical upgrades might be needed.

Fleet charging behavior is assumed to largely follow a hub-and-spoke model, with most charging expected to occur in private fleet depots with vehicles returning to the charging hub daily or even multiple times during the day to recharge. Most fleet operators will likely optimize their depot charging behavior to meet their routinized driving needs and fleet size. Long-distance freight operators are expected to use public charging spots along highways. Heavier duty vehicles are expected to rely on DCFC charging due to their large energy demand and time spent on the road.

MDHD port counts are largely driven by MD and HD fleet depots. Within the EVSE serving the Medium and Heavy-Duty vehicle segment, public charging (Hub) plays a key connectivity role, and has large local load impacts, but absolute counts are much lower due to higher sharing.

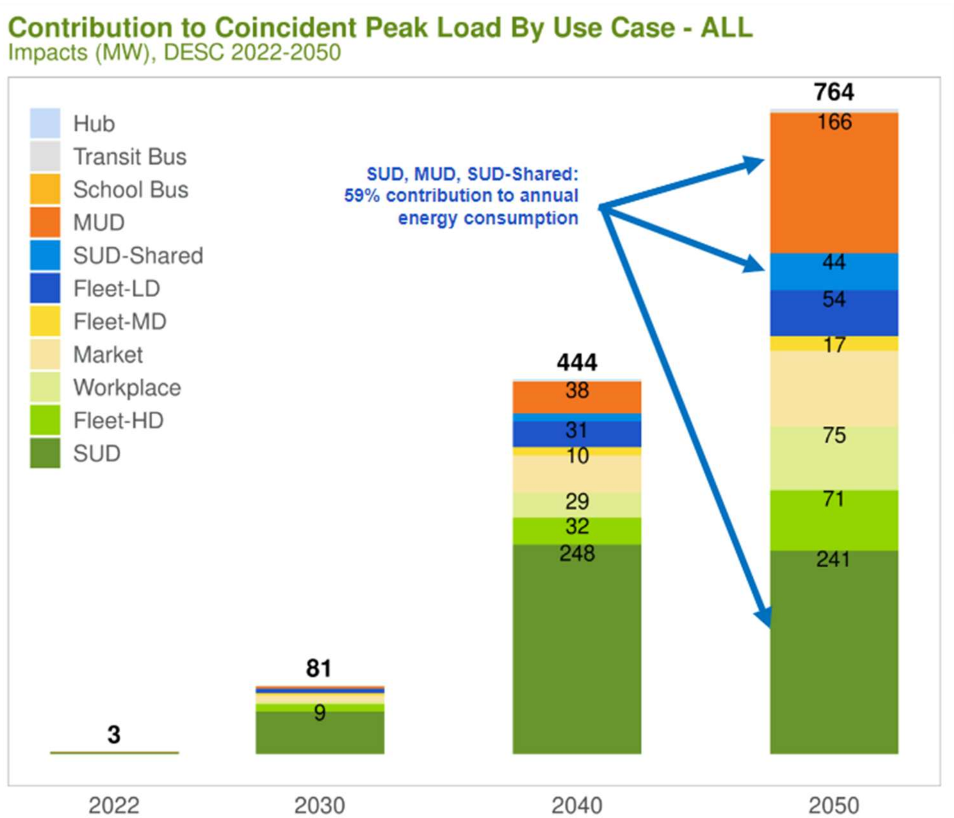
Q. WHAT ARE KEY DRIVERS OF THE LOAD FORECAST?

A. The load forecast in the DESC territory is driven by multiple dynamics. Electric vehicle adoption is growing exponentially in DESC's service territory and will continue due to the combined effects of OEM investment, consumer demand and strong policy support. At the same, charging infrastructure build-out is expected to increase to fill the gap between supply (ports) and demand from vehicles. EVSE development is increasing as the number of PEVs increase and the share of PEVs increasingly shifts toward full BEV, and ports are built at higher capacity levels. Together these three-fold trends mean that the contribution to the DESC service territory by electric vehicle load will be exponential throughout the forecast horizon. Annual energy consumption from LDVs is driven by SUD charging. Annual energy consumption from MDHDVs is driven by MD and HD depot charging.

While fleet owned vehicles, and the associated EVSE make up only a small portion of the total PEV on the road for DESC in the forecast, these vehicles contribute disproportionately to the energy and demand impacts in the territory due to the longer duty cycles, higher VMT, and generally lower efficiency (miles/kWh) of these vehicles. Along with increased availability of public and workplace ports, and increased adoption of MDHD PEVs, this contributes to the declining share of energy and coincident peak demand contributed by SUD home charging in the forecast over time, as seen in Figure 2.[23]

[23] *See* 2023 IRP Forecast: DESC Electric Vehicle & Charging Infrastructure, pg. 29

Figure 2. EVSE Contribution to DESC Annual Peak Load by Use Case[24]



Q. DOES THIS CONCLUDE YOUR PRE-FILED DIRECT TESTIMONY?

A. Yes, it does.

[24] See exhibit SR-1 for complete EVSE use case key.